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A Computer Based Application for Ship Survey Reporting

by

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At the time when this application was being considered, Oceanking was considering improving software engineering practices by using software development methodologies. The usefulness of CommonKADS, which is a methodology for KBS development, was evaluated during the development of this system. CommonKADS supplies modelling techniques to represent acquired knowledge from multiple perspectives, thus documenting knowledge in a modular fashion which is suitable for analysis and re-use. CommonKADS modelling techniques were applied to one module of VESSELL which supports the assessment of paint quality on ships. The experiment helped Oceanking to improve their project management procedures; on the other hand, the use of CommonKADS modelling techniques added substantial overhead to a small scale project. The modelling techniques appeared to be more useful for constructing knowledge based systems which acted in an ”expert advisor” role than knowledge based systems which acted in a ”decision support” role.

Keywords :

A Computer Based Application for Ship - Survey Reporting

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Abstract

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At the time when this application was being considered, Oceanking was considering improving software engineering practices by using software development methodologies. The usefulness of CommonKADS, which is a methodology for KBS development, was evaluated during the development of this system. CommonKADS supplies modelling techniques to represent acquired knowledge from multiple perspectives, thus documenting knowledge in a modular fashion which is suitable for analysis and re-use. CommonKADS modelling techniques were applied to one module of VESSELL which supports the assessment of paint quality on ships. The experiment helped Oceanking to improve their project management procedures; on the other hand, the use of CommonKADS modelling techniques added substantial overhead to a small scale project. The modelling techniques appeared to be more useful for constructing knowledge based systems which acted in an "expert advisor" role than knowledge based systems which acted in a "decision support" role.

1 Introduction

Shipping companies that own or manage ships keep track of the ships' condition and requirements using various filing systems. For every ship there is a separate file with a considerable number of documents and reports. These documents are generated by the master or the first engineer at specified intervals (usually monthly), or are the result of technical surveys. Ship technical surveys are performed for a variety of reasons and can be classified into surveys required by the Class and performed by Class surveyors, and surveys performed upon request of the ship owner or the technical manager, carried out by qualified engineers. In the latter case, the objective is to evaluate the present condition of the ship (hull structure, cargo holds and tanks, main propulsion and electrical machinery,
auxiliary equipment etc.); to assess the requirements for repairs; and possibly to estimate the repair cost. It is common practice to take a considerable number of photographs of defective ship parts or equipment to accompany the survey reports. However, common practice does not yet extend to the standardisation of reporting formats; every ship surveyor has his particular reporting style, and any comments or recommendations may be subject to different interpretations by the shipping company management. This may create problems for shipping companies due to the variety of reporting formats used, and the inherent possibility of inconsistent filing in a manual filing system. As the planning of the repair works and dry-docking of a ship depends to a large extent on the due items reported during these surveys and on the monthly reports of the ships' chief engineers and masters, it is important that these surveys are as complete and accurate as possible, and standardisation of format should bring these benefits.

This paper describes a software application known as VESSELL which aims to alleviate these problems by supporting the tasks carried out by a surveyor in an orderly and consistent manner, and ultimately to enable the electronic filing of ship surveys. This system was built by Oceanking Maritime, with support from ESSI project 10327 (CATALYST).

2 Domain Knowledge Acquisition

A software system to assist in ship survey reporting and fleet monitoring - especially one which includes a detailed ship model such as the system described above - must include domain specific knowledge which is very broad, because there are many different aspects which a surveyor must check, some of which (such as paint system selection) have several options which are affected by various constraints. Such knowledge has to be collected from various sources:

- Interviews with marine engineers performing ship surveys. Such interviews include the preliminary, information gathering discussions which enable the formation of expertise models as well as the expert walkthroughs of the knowledge structure in the models built, for correction and completeness checking.

- Additional knowledge sources such as complete survey reports from shipping company files and information gathered from shipyards, concerning labour costs for various operations.

- Literature from books as well as forms describing recommended procedures for official surveys. These comprise another major source of specialised information which can be used for knowledge modelling.

2.1 CommonKADS

It was decided that this project would make use of a methodology as a technological experiment. The chosen methodology was the CommonKADS methodology. CommonKADS is a comprehensive methodology for the construction of knowledge-based systems incorporating ISO 9000 guidelines. It was developed in a series of projects supported by the ESPRIT initiative of the European Union. When building an application using CommonKADS, a knowledge engineer first elicits the knowledge used by the expert and then builds a set of models which describe the knowledge of the expert, without being concerned with the restrictions of the actual implementation. The set of models is collectively known as the CommonKADS model set. The CommonKADS model set consists of six models (organisation, task, agent, communication, expertise and design models). The first four models are specifically geared to modelling the organisational environment of a KBS; the knowledge that helps to carry out a specific task is described in an implementation-independent manner by the expertise model; and the design model may be developed to facilitate the transition from the expertise model to the actual implementation environment, by making design decisions and preferred programming techniques explicit, as well as frequently preserving much of the structure of the expertise model.

The knowledge within the expertise model is further subdivided into two categories: domain knowledge and control knowledge. Domain knowledge is static, and consists of the concepts, relations and facts that are needed to reason about a certain application domain. This knowledge does not contain information about the way to solve a problem. Control knowledge is further subdivided into two categories: inference knowledge and task knowledge. The inference knowledge describes the individual reasoning steps which operate on domain knowledge, and the task knowledge describes how to decompose a top-level reasoning task into sub-tasks and ultimately into individual reasoning steps. The knowledge can be modelled using a software support workbench such as ILOG's KADS Tool [1], which supports the CommonKADS method. The use of such a tool facilitates verification, validation, maintenance and expandability assisting with the management and development of a fully instantiated CommonKADS model set.

2.2 Modelling knowledge for paint system evaluation

The type of knowledge which needed to be acquired for this project concerned the ship coating condition evaluation and repair cost estimation. For example, when a ship owner wants to paint a cargo hold the recommended list of coating systems are:

1. Standard system
2. Zinc-Silicate system
3. Epoxy system

If the owner selects an epoxy system, the surface under consideration should be blast cleaned to a good quality, whereas if the standard system (conventional paints) is selected, in certain cases the surface could be pre-treated by some inferior means, e.g. mechanical wire brushing. When the ship surveyor wants to make a coating cost estimation for some location on the ship he has to consider different factors such as ship location, existing paint used, operating environment, cargo transferred, required pre-treatment, etc. All this knowledge maybe represented graphically in a CommonKADS inference structure diagram, as depicted in Figure 1. Such a diagram may be further decomposed in order to obtain more detailed information; Figure 2 shows more detail of the steps required to "estimate cost".

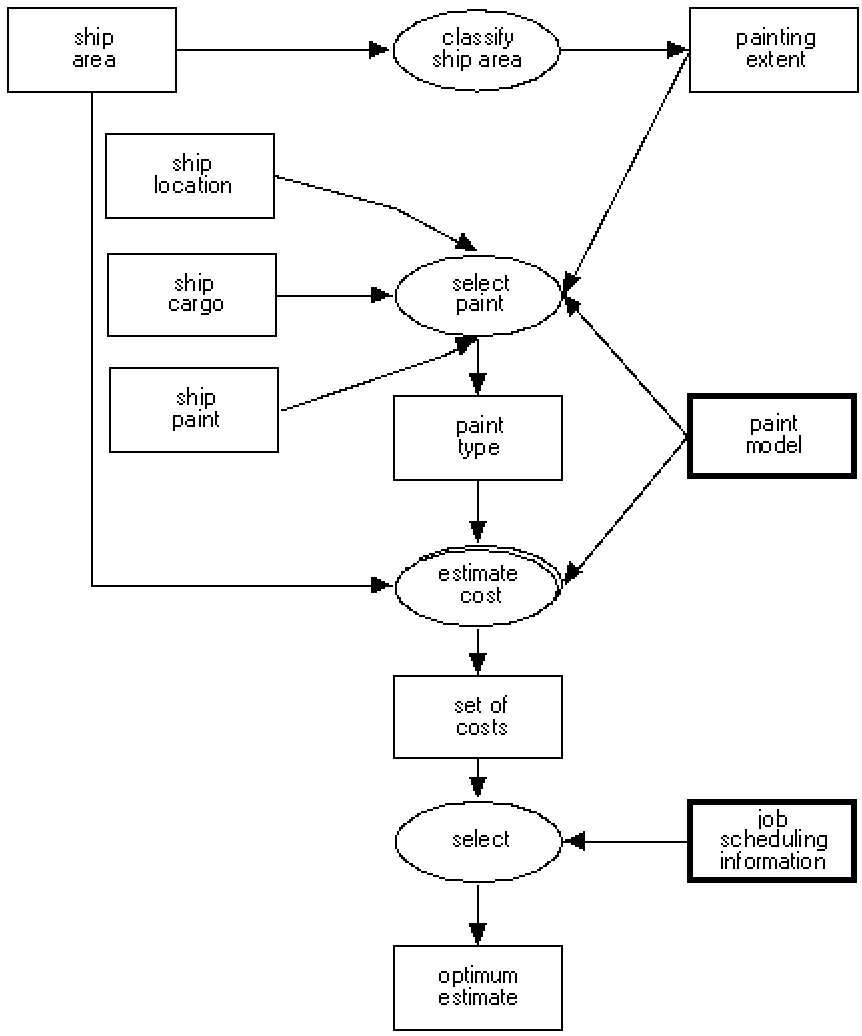

Figure 1: The ship coating selection and costing procedure

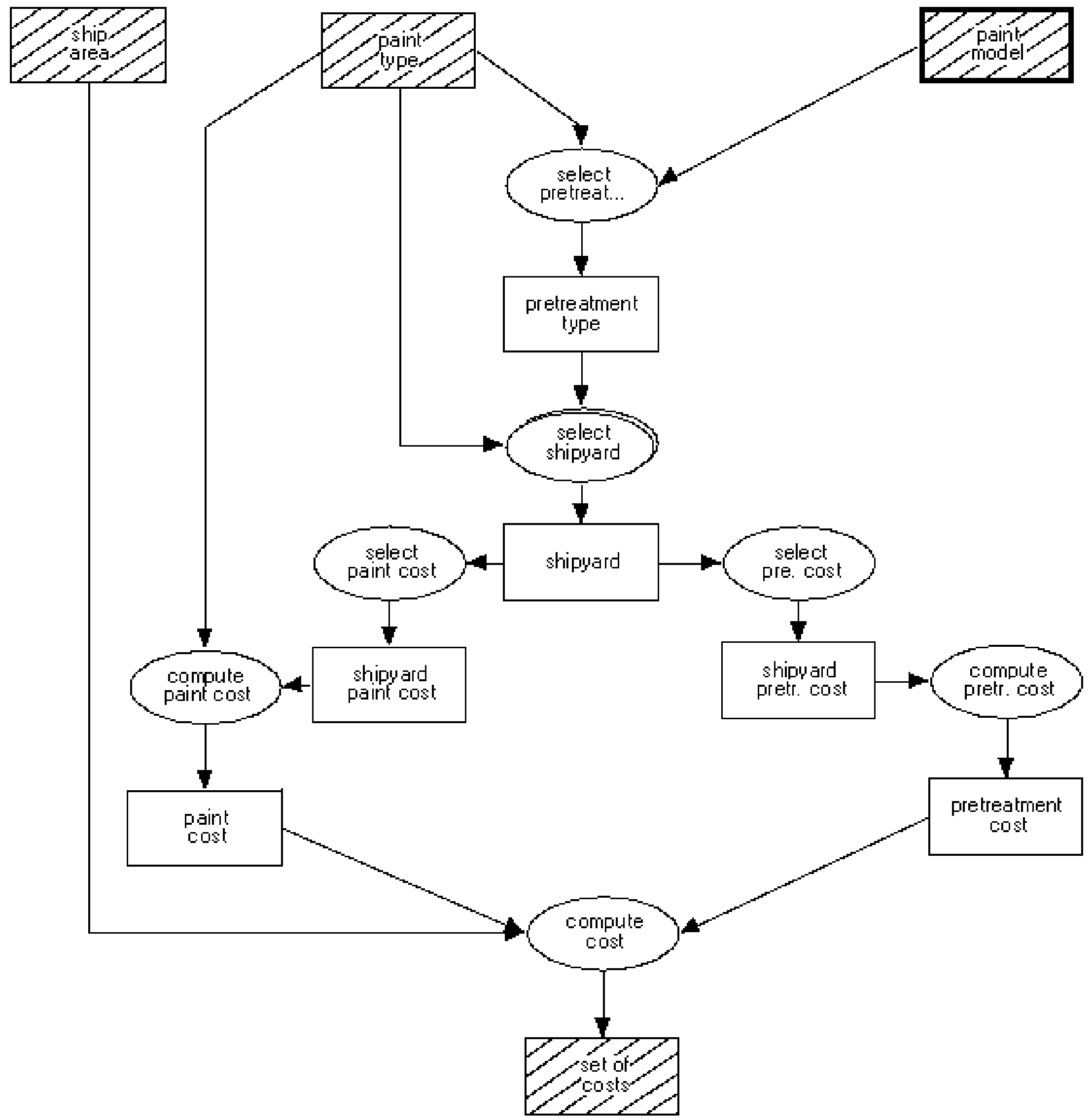

Figure 2: The "estimate cost" procedure in detail

The aforementioned figures describe the procedure followed and indicate most of the required elements but they do not give raw data, like the specific relations existing between paint types and ship locations. This kind of knowledge is described in the domain layer of the expertise model. In the present case the guideline which was used to fill up the domain layer is depicted in Figure 3, where most of the necessary relations are presented but still the description is generic. The next step is to describe every relation using specific data. Figure 4 shows an instantiation of the “ship location **requires** paint systems” link for a particular ship location (the boottop). This collection of diagrams documents expert knowledge of important relationships and options available when selecting and costing paint systems.

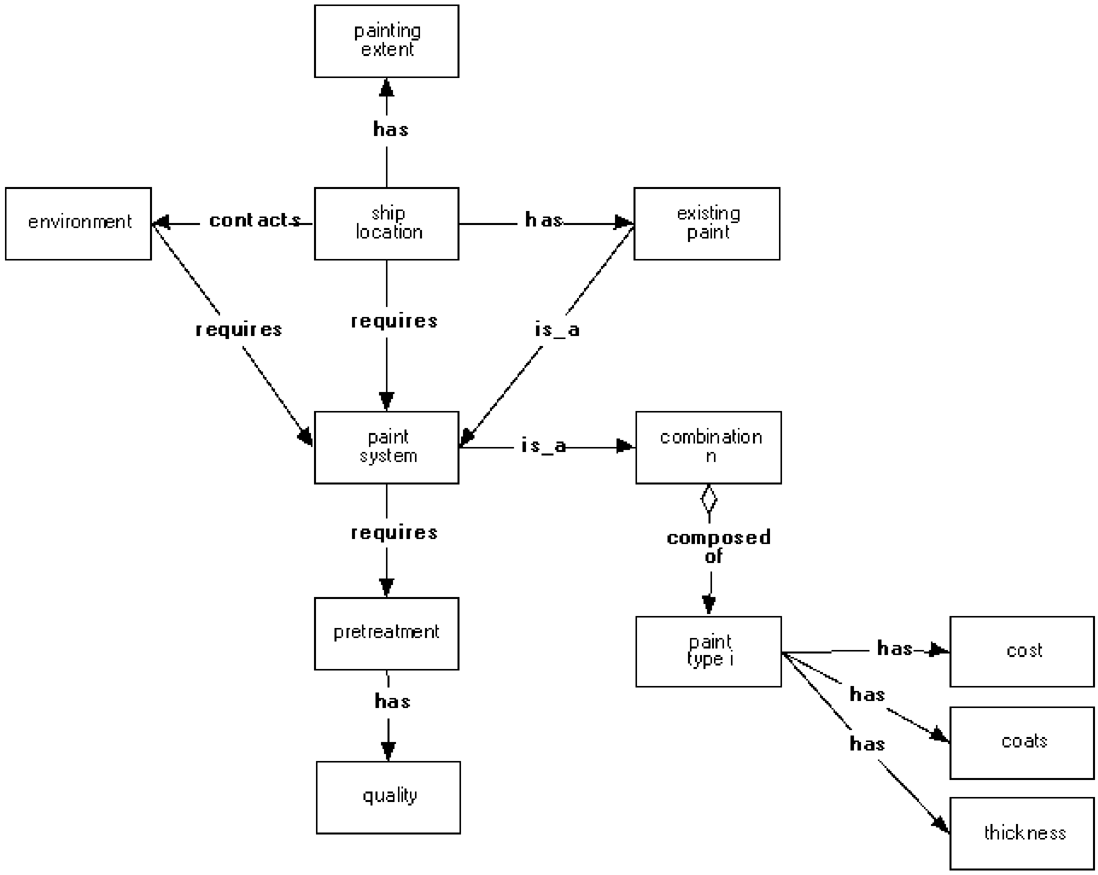

Figure 3: Part of the relations existing between domain layer data

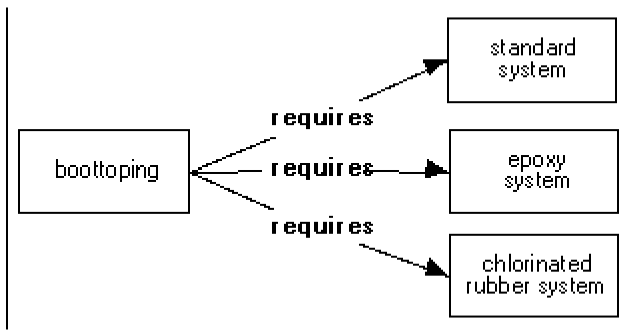

Figure 4: A specific "ship location" and the appropriate "paint systems"

3 Work Performed

The project was carried out by Oceanking Maritime Systems Division, with one staff member working full time on the project, and another staff member carrying out project management. A third staff member was involved in software support, and eventually took on the project management role as well.

The technology experiment included three weeks of training in Edinburgh for one member of staff. This training included:

- three days' training on CommonKADS project management techniques;
- a week's training on building knowledge based systems using CommonKADS, and on eliciting knowledge for knowledge based systems;
- a week spent on initial work on CommonKADS modelling, supervised by the consultants who performed the training.

It was decided that a CommonKADS support workbench was needed to support creation and maintenance of the CommonKADS models for the VESSELL system. After reading an evaluation of different CommonKADS workbenches produced by some of the consultants on the project [2], Oceanking decided to purchase KADS Tool. As KADS Tool is not available on a PC, the system was installed on Sun hardware at the National Technical University of Athens, whose assistance is gratefully acknowledged.

CommonKADS also makes some recommendations for project management: the whole software development is organised and monitored by the project management activity cycle (PMAC) which is based on Boehm’s spiral model [3] and handles KBS development as a flexible, iterative process.
The project was organised according to the recommendations of CommonKADS; the main phases of the KBS phase of the project were:

Cycle 1

- Acquire suitable platform to run KADS Tool.
- Acquire KADS Tool.
- Complete “photograph management” subsystem.
- User Interface functionality / features.
- Collect domain information

Cycle 2

- Install KADS Tool
- Acquire tool skills.
- Develop communication model for present “condition evaluation” software.
- Specify behaviour for “paintwork cost estimation” subsystem. Model the Task, Inference and Domain levels of the CommonKADS Expertise Model.

Cycle 3

- Specify content (Domain completed).
- Complete Inference and Task layers for “cost estimation”.
- Investigate design model applicability.
- Develop demo for user evaluation.

Cycle 4

- Carry out dry runs and test cases in order to validate behaviour of demo pilot version.
- Deliver a pilot version consisting of three modules of VESSELL with paint subsystem to the user for evaluation and feedback.

Cycle 5

- Build expertise model
- Implement the model
- Deliver an alpha version to the end user.
- Dissemination

Cycle 6

- Deliver a beta version to the end user.

Cycle 7

- Deliver the final version to the end user.
- Dissemination

The milestones of the project were:

1. Deliver a prototype version consisting of three modules of VESSELL with “paint” subsystem to the user for evaluation and feedback. (end of Jan ‘95).
2. Deliver and evaluate alpha version (March/April ‘95).

3. Deliver and evaluate beta version (May/June ‘95).
4. Final version delivered to the user after the evaluation cycles. (end of July ‘95)

4 Design and Implementation

Every ship type is a complicated system that differs considerably from other ship types and in some respects from other ships of the same type. Furthermore a shipping company may want to access only specific components of a ship. These facts imply that a software system addressing the area of survey reporting should be flexible enough to accommodate the wide ranging requirements of the potential users and the large variety of surveyed ship types [5]. Within the software system described here, a ship is represented as a hierarchy of functional units, sub-units, systems, and equipment. For example the basic units for a typical general cargo/tanker ship are the following:

1. General Information (including Certificates/ Classification)
2. Hull & Deck
3. Holds/Tanks
4. Propulsion & Aux. Machinery
5. Cargo Handling Gear/Pumps
6. Navigation & Accommodation

All basic units are further subdivided. For example, the Holds/Tanks node can be divided into one or more of the following sub-units:

1. Hold
2. Tank
3. Forepeak Tank
4. Topside Tank
5. Double Bottom

One of the main considerations for the design of the system was to transmit visually this conceptual tree of the ship and the constituent branches to the end user. A number of user interfaces were designed and after extensive user evaluation and feedback, it was decided that every tree node should correspond to a form that appears on screen as a separate window. By clicking on buttons the user can navigate through the ship parts to access all ship components. For example, Figure 5 shows how the user can access the components of the deck plating by first clicking on “Hull/Deck”, then selecting “Deck”, then selecting “Deck plating”.

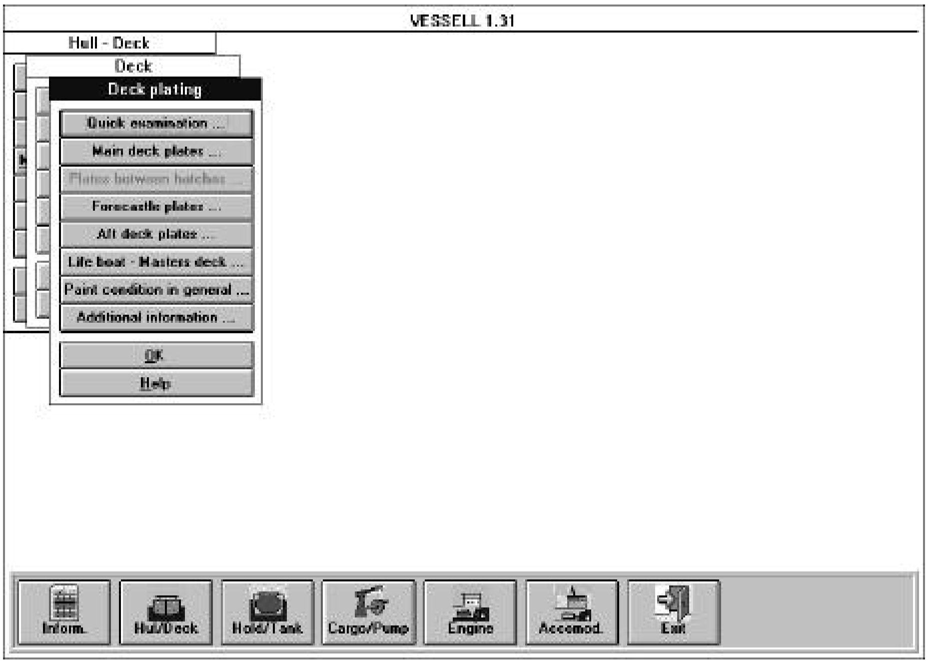

Figure 5: ***The main form with the options for "Deck plating"***

During the development of the user interface a number of objectives were taken into consideration :

1. The various forms confronting the user on the computer screen should be consistent in appearance.
2. All text should be self explanatory with additional on-line help.
3. Navigation from node to node should be easy.

The user interface serves as a front end which collects information through interaction with the user. The collated information is stored in a database from which it can be viewed and printed now, or recalled and altered later. This approach allows the handling of the data stored in the database by other programs/modules, increasing the flexibility of the proposed system.

The user interface also requires photographs of ship components to be displayed. The photographs or video film snapshots of the defective ship parts or equipment which may be taken during the survey [4] can be linked with the corresponding equipment/ component (Figure 6). The application provides tools for image digitisation and storage in the database. Input can be from digitisers, from video playback frame capturing or from digital cameras. The photographs are displayed using a particular type of form.

Some of the design aspects which assist this application in reaching the goals of expandability and maintenance are:

1. The modularity of the user interface was used as a guideline for designing the underlying database structure. For every ship basic unit (e.g. Hull/Deck) there is a corresponding table in the database that stores all related information.

2. Mapping documents were used for linking all code related to every ship component throughout the modules.

3. A number of procedures were documented and provided to assist the developer in handling specific tasks, such as: adding ship components to the user interface, providing the support of new ship types, etc. As a result, if the developer wants to remove a specific piece of machinery, he can refer to the aforementioned mapping documents/ maintenance methods where he will be supplied with the procedure he has to follow and the pieces of code he has to write, or alter, for carrying out his task.

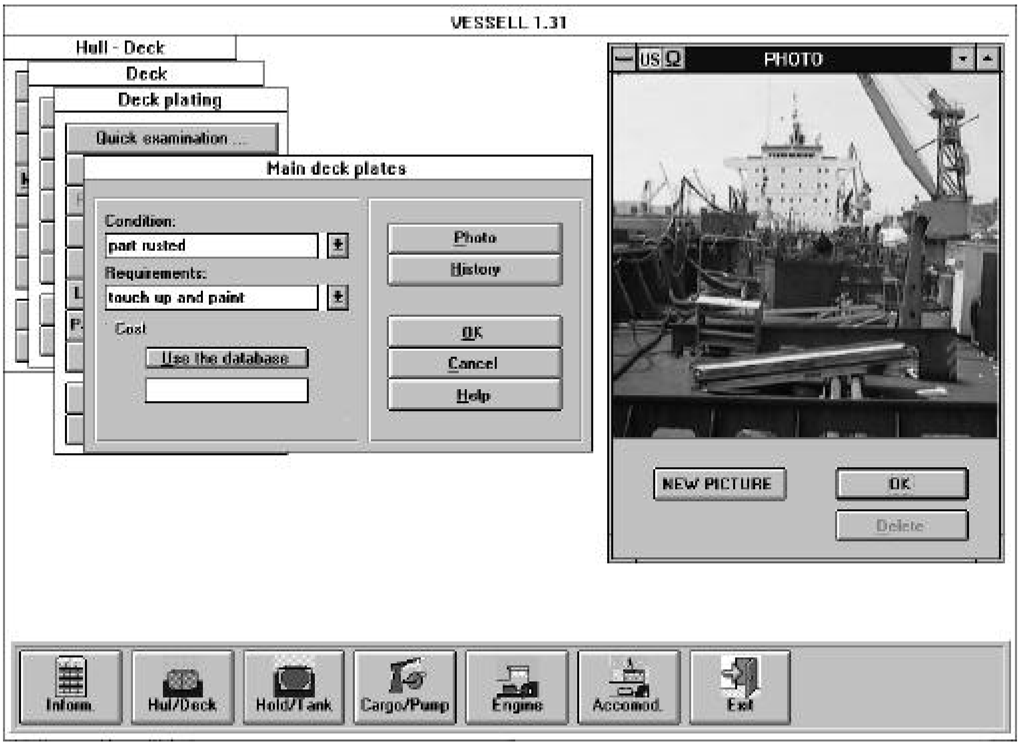

Figure 6: The form that handles images

During an interactive consultation for report preparation following a survey, the appropriate modules for the particular ship type are loaded on request and the user of the facility inputs up-to-date information about the condition of items of the ship surveyed, the requirements for repairs and an estimation of the cost of repairs for ship parts and equipment as well as any additional comments. In the following paragraphs a walk-through of a typical consultation is presented. After the introductory form, the user is presented with the main working area (Figure 7). At the bottom of the window there is a toolbar on which each one of the ship modules, described in the previous sections, is represented by a button with a relevant picture. In this example case the Hull/Deck module has been selected. From this point on, all options that are available to the user are presented as a list of buttons. By selecting one of the relevant options on consecutive input forms (see Figure 1), the user can reach the preferred sub-unit, system or equipment/ component. In Figure 8, the “Main deck plates” component has been selected for input/output. All the above information, entered by the user, is used by the application for compiling the survey report of the particular ship. The information is also stored in the database for future reference.

The reporting is handled by a separate module. Specific information from various surveys can be retrieved from the database in custom made formats. In this way, historical data of damages and repairs, as well as class related information (e.g. due items) can be easily inquired and reported. The end result is a document of the form appearing in Figure 9, which shows for every ship all the information available from a survey as well as the estimated cost for repairs.

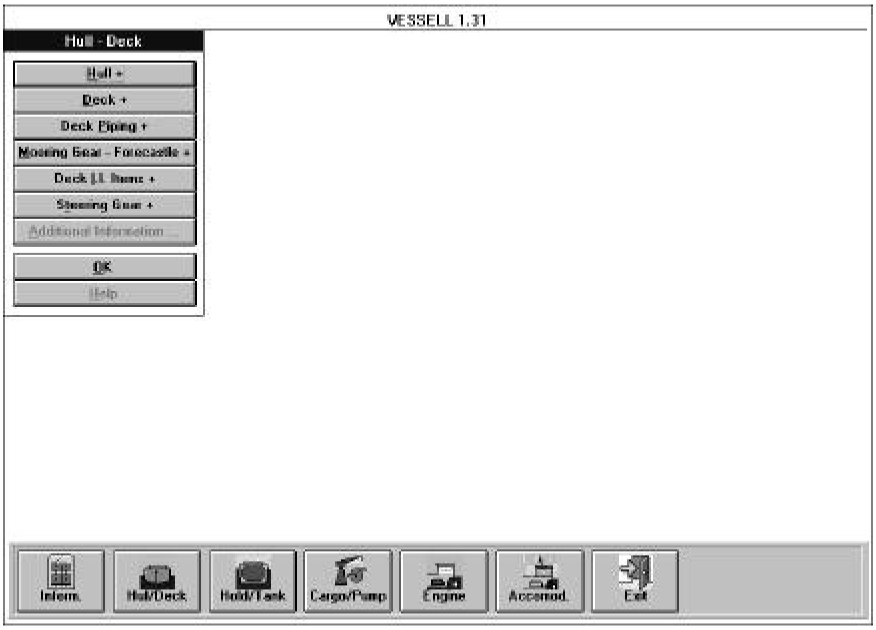

Figure 7: The main form with the Hull/Deck module selected

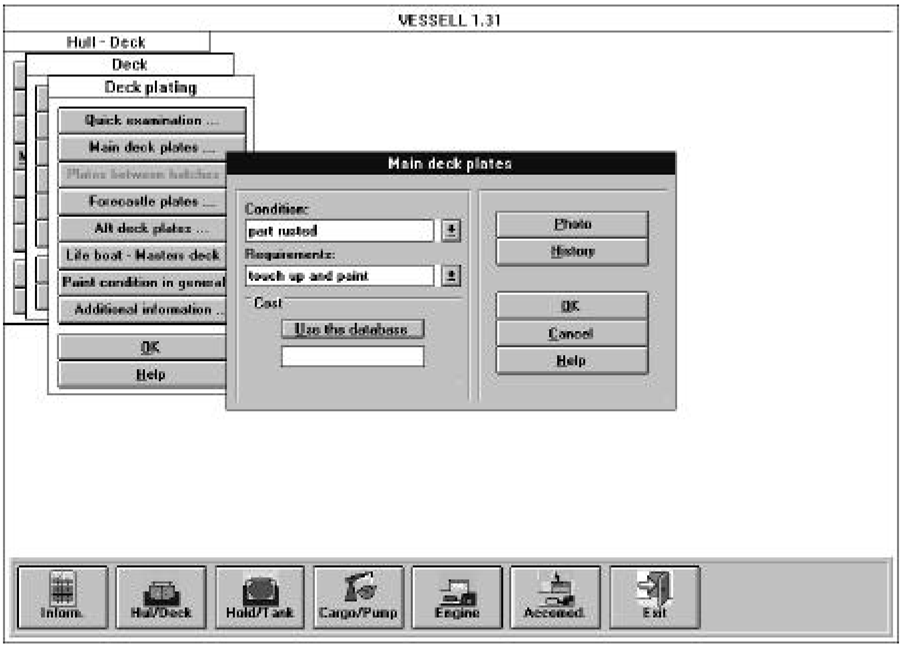

Figure 8: The form that handles data for all components

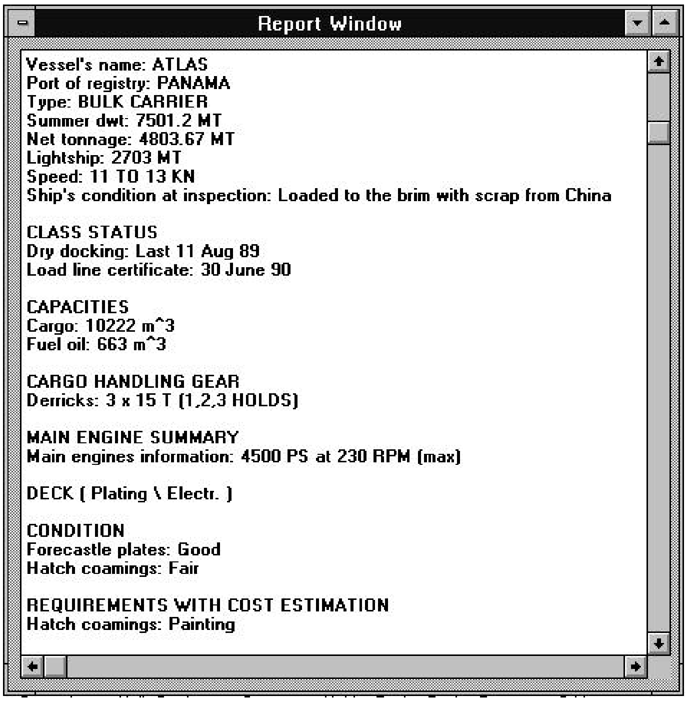

Figure 9: A typical report

5 Results and Analysis

5.1 Business success

At the conclusion of the technological experiment, a prototype of the VESSELL system had been completed, which incorporated a “marine paint advisor” module. The commercial success of a prototype is difficult to measure. However, the project has produced at least one commercial breakthrough, because the careful analysis of the task of paint advising attracted interest from a new potential client; the clear presentation of the coating selection procedure with cost estimation, developed using CommonKADS techniques, was helpful in establishing a solid technical background description of the system under development.

5.2 CommonKADS

The CommonKADS techniques for domain modelling were found to be useful for this domain, although the techniques for inference modelling were found to be less useful. It was observed that:

- CommonKADS project management techniques proved useful, even for this relatively small project. The project management cycles helped to determine the milestones described in section 3.5, and when the project management was taken over by one member of staff from another, the new project manager was able to become familiar with the project in about one month.

- CommonKADS modelling produces flexible models which can easily be adapted to changes in the operating procedure or in the overall goal of the paint assessment task. The generation of models with potential re-usability is one of CommonKADS' key advantages over simpler techniques such as flow charts.
- The generation of CommonKADS models for a single small project can produce a considerable overhead. If there is no need for reusable models, then CommonKADS may be discarded in favour of a less time-consuming modelling method. However, some kind of modelling should be performed, to support future maintenance of the current system.

Oceanking learned that:

- CommonKADS does not need to be used in its entirety in order to be useful. It is possible to choose and use only those models which appear relevant to a project;
- Some of the work required when solving a knowledge-based task does not require much expertise. This can be identified using the CommonKADS Task Model or, as in this project, by defining a flow chart as a top level representation of the problem;
- Supporting software for CommonKADS, such as KADS Tool [1], is very helpful in developing CommonKADS models. However, the software is currently restricted to UNIX platforms, which makes it difficult to integrate within Oceanking's business environment;
- CommonKADS seems to be more appropriate for knowledge based systems which take over the role of an expert advisor, rather than systems which act as decision support systems for existing experts. The parts of CommonKADS which are most appropriate for "expert advisor" systems (the inference and task structures of the expertise models) are better developed than the parts of CommonKADS which are most appropriate for "decision support" systems (the Communication Model). The modelling of domain knowledge in the CommonKADS Expertise Model is useful for both types of system.
- The CommonKADS "lifecycle" approach to project management is relatively easy to learn, and provides benefits even for small projects;
- CommonKADS generates sufficient diagrams and documentation to assist new staff members in "coming up to speed" on an existing project. The documentation was also helpful in communicating between different partners in a joint project (in our case, ourselves and the consultants);
- The major benefits of CommonKADS appear if the models are re-used on future projects. For a single small project, CommonKADS adds a significant overhead to the time required for the project; our estimate is that more than 40% of the cost of the "marine paint advisor" project can be attributed to CommonKADS.

The part of CommonKADS with the largest long-term influence is likely to be the project management model. It was very interesting to be exposed to this different approach and some of the features and suggestions of the CommonKADS project management methodology will be strongly considered for gradual incorporation in future projects of an appropriate nature.

6 Conclusions

The VESSELL system is a software application which can keep track of the condition of every ship down to the level of structural elements and machinery items. In this way the user can calculate the cost for individual items or tasks (like coating) and keep track of all due items. Specific items (e.g. a pump type) which appear on more than one ship can also be followed up. All collected information is printed in a structured and uniform way. This software facility uses knowledge based modelling and representation techniques as well as a user friendly user interface. Modularity, maintainability and extendability were considered from the very beginning as key design factors and the described application was developed along these guidelines, using a methodology known as CommonKADS. As a result, its customisation to the specific needs of a shipping company is considerably facilitated.

Part of the project was conducted as an experiment to evaluate the usefulness of CommonKADS for KBS projects. It was concluded that the depth of coverage and the wealth of methodological insight offered by the CommonKADS methodology was highly appreciated, and was particularly valuable for the company at the strategic level in reassessing the policy for the overall project management in product development. However, the cost and limited hardware platforms of the CommonKADS support tools was considered to restrict the potential of CommonKADS.

As a result of the CATALYST experiment, Oceanking would consider the use of the CommonKADS methodology in projects with KBS development requirements where expert advisors will be developed (rather than decision support systems) provided that the tools were available under a Windows environment. It must be noted here, however that the marine industries where the activities of Oceanking are directed, is a very conservative market so that an "expert advisor" is less often requested and more difficult to market, than a "decision support" system for existing experts.

Acknowledgements

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